Objective Measurement of Personality with HBR-Tools: Chances and Boundaries

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ABSTRACT

Measuring personality is a complex task. Besides difficult content-based problems there are some psychometric issues to be met, i. e. socially desirable answering tendencies. The present study uses simulation-based objective personality measurement to meet these psychometric issues. Computer-based "guard" and "stray" scenars are developed and tested in two samples of Special Forces applicants respectively soldiers. A construct model has been predefined and used to develop behavioural markers in the scenars. These markers are the basis for the subsequent analysis. Results show that a substantial number of behavioural markers do not show sufficient variation and therefore have to be removed from further analysis. With the remaining markers the construct model is evaluated. The predefined model couldn't be identified in the data, but an alternative model could be established at least for the "guard" scenar. Further development of the scenars is necessary in order to meet the requirements of an efficient and effective diagnostic instrument.

1.0 INTRODUCTION

Measurement of personality is a really complex task. First, it appears to be more difficult to define exactly the different personal abilities, especially to differentiate between these constructs. Second, to operationalize the constructs is more difficult because it means to deal with subjective perceptions of social situations. Third, beside these more psychological aspects there are some psychometric issues. The classical questionnaires which measure personality are vulnerable with respect to answering tendencies. This is especially the case in selection contexts, in which the candidates try to make a positive impression of themselves. Answering tendencies in this context mean socially desirable answering, or in a more extreme wording: faking results.

Despite these challenges it becomes more and more necessary to deal with the measurement of personality. In military contexts, the demands related to personal abilities rise. For the German Federal Armed Forces (Bundeswehr) the number of missions in foreign countries has increased in the last two decades. This causes increasing demands concerning the personality of soldiers. These new challenges include dealing with different cultures or producing adequate behaviour in dangerous situations. Concerning the answering tendencies, the research of the last years follows two different directions. First, the answering formats are varied so that candidates are forced to decide between two equivalent answers to suppress faking. In this case, they have no possibility to direct their answering in a social desirable manner. This approach has the disadvantage that candidates often stop answering the questionnaire. The selection between two equivalent answers often means a choice between the devil and the deep blue sea. Second, measurement of personality can be implemented in more or less real life situations, even with the computers. These simulations require reacting in complex situations so that candidates are not aware of the psychological aspects that are measured. Because of this unawareness they are not able to control their behaviour in a social desirable way.

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14. ABSTRACT
Measuring personality is a complex task. Besides difficult content-based problems there are some psychometric issues to be met, i. e. socially desirable answering tendencies. The present study uses simulation-based objective personality measurement to meet these psychometric issues. Computer-based guard and stray scenars are developed and tested in two samples of Special Forces applicants respectively soldiers. A construct model has been predefined and used to develop behavioural markers in the scenars. These markers are the basis for the subsequent analysis. Results show that a substantial number of behavioural markers do not show sufficient variation and therefore have to be removed from further analysis. With the remaining markers the construct model is evaluated. The predefined model couldnt be identified in the data, but an alternative model could be established at least for the guard scenar. Further development of the scenars is necessary in order to meet the requirements of an efficient and effective diagnostic instrument.

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The present study is engaged in the context of this last research direction. The aim of the study is to develop an objective and efficient diagnostic instrument that can be used in personnel selection situations. The study was conducted by Industrieanlagen-Betriebsgesellschaft mbH (IABG) under the order and supervision of the Psychological Department of the German Ministry of Defence. IABG used an improved version of the so called assessment demonstrator and the methodology of Human Behaviour Representation (HBR) to develop a new assessment instrument. As a last step of the study, the HBR-Monitor shell be used to generate an automatic report of the diagnostic results, so that a personnel selection recommendation can be made.

1.1 The HBR Approach

HBR uses methods of cognitive modelling. The idea of the approach is the existence of a level of basic cognitive mechanisms that serve as a fundament for personal attributes on the one hand and differences between candidates on these attributes on the other hand. In the framework of HBR, personality can be modelled as an interaction of parameters of an information processing system. HBR respectively cognitive architectures can be understood as "relatively complete proposals about the structure of human cognition" (Anderson, 1993, p. 3). These proposals allow using a consistent theoretical basis for cognitive information processing. In doing so, HBR does not look at single cognitive mechanisms or single personality attributes, but postulates systems that describe information processing, goal achievement and activity initiation as a whole (ACT-R: Anderson, 1983; SOAR: Newell, 1992; PSI: Dörner, 1999; Cogent: Cooper, 2002).

The HBR approach is build on the PSI theory of Dörner (1999) that models personality in a framework of cognitive architecture as patterns of information processing (Schaub, 2001). Personality in this framework is defined as persistent, so that the structures and parameters of the system are stable. The theory does not only model cognitive processes, it also deals with integrated dynamic models of actions, motivations and emotions. So it is possible to describe psychological functions and structures that go beyond single personality factors. The postulated structures and processes enable the cognitive system to achieve goals and satisfy directly or indirectly motives. Goals are defined as activated motives that are able to control actions. In this framework, goals are the central structure of the PSI system. Aspects of the theoretical model include different processes of goal generation, goal selection and goal achievement. Independent of these processes are some general parameters that define rules of information processing and control the functioning of the system. The most important of these parameters are "degree of resolution", "level of activity", "flexibility" and "externalisation", which are defined as follows:

- "degree of resolution": accuracy of information processing
- "level of activity": speed of information processing
- "flexibility": probability of interruption of the current goal by the activation of a concurrent goal
- "externalisation": probability of interruption of the current goal by external stimuli

Candidates can be distinguished first with regard to their actual values on these parameters and second with regard to the range of possible values of the parameters. The actual values of the parameters reflect the adaptation of the information processing system to the situational demands. The range of possible values marks the upper and lower boundary of the capability of the information processing system to adapt to special situational demands. With respect to the measurement of personality this means that one has to deal with both aspects. The actual parameter value shows the degree to which a person has adapted to a situation. The range of values gives a deeper insight to the ability of a candidate to adapt to different situations.

The HBR approach as well as the PSI theory has been tested in several computer simulations. These simulations have compared the postulated information processing system with the behaviour of real-life

persons (cf. Dörner, 2000; Schaub, 1993, 2001). The results support the validity of the HBR approach respectively the PSI theory.

1.2 HBR Simulations – The "guard" and the "stray" Scenar

The present study employs the PSI theory respectively the HBR approach to develop two different computer based simulations (Schaub & Stroscher, 2008). The simulations are objective, standardised and application-oriented diagnostic instruments. Their goal is to identify desirable and important personality attributes for applicants and / or occupants of military positions. The simulations are called scenars. The first ("guard" scenar) deals with the interaction of a simulated guard with a burglar in a business building. The second ("stray" scenar) relates to a group of persons visiting a town.

The scenars represent demands that can be found in either military or civil contexts. The candidates are confronted with complex and risky situations in the framework of a computer simulation. They have to make critical decisions by taking over the role of the protagonist of the scenar. By steering the protagonist through a virtual room with several critical situations, the decisions can be recorded and evaluated with regard to the personal attributes in focus. The framework of the scenars offer the possibility to bring up a cover story, in which the candidates are engaged without realizing which aspects of their behaviour are monitored and what kind of evaluation is done. So the options to show socially desirable behaviours are minimal and personality can be measured "as it is". In the following the two different scenars "guard" and "stray" are described more closely.

In the "guard" scenar the guard is responsible for controlling a stock depot. The depot consists of several rooms inside a building and an area outside. At the beginning the guard is inside the guard-room. Before starting the measurement the candidate gets detailed information on how to steer the guard inside the scenar. He can take as long as he needs to exercise the steering so that at the beginning of the measurement section the influence of familiarity with the necessary computer handling capabilities is minimal. In addition to that, the candidate gets some framing information about his task as a guard, about the building in which he finds himself and about some additional duties in the course of the action.

After starting the measurement section the guard hears an undefined noise from outside. From now on he has several options how to react to the specific situations developing. He can do nothing, he can go and investigate the noise, he can try to call the police and so on. Depending on how he reacts the scenar is continued. The scenar is designed in such a way that the guard discovers a burglar and he has to react in an adequate manner. Fulfilling the idea of a simulation many options lead to this point. Every decision of the candidate leads to different outcomes, which are recorded. His actions on his way to capture the burglar define different aspects of personality measurement.

In the "stray" scenar, the candidate takes over the roll of one person in a group of five. The situation is defined so that the group has strayed in a city. At the beginning of the scenar, one of the members of the candidates' group has an accident so that he needs medical help. Several tasks are defined for the candidate in the scenar: He has to reach the railway station, the group has to reach the railway station, too, he has to coordinate his actions with the rest of the group, he should consider the danger caused by hooligans and he should keep in mind that no one in the group is armed. In the course of action, the group meets other groups (e.g. hooligans) or single persons (someone who can help find the way to the railroad station). The candidates group suggests to the candidate to take the leading role by asking for advice, acting indecisive and so on. The choice of actions the candidate takes over the course of the scenar offers ample opportunities to measure personal abilities especially concerned with interaction and / or leading behaviour.

1.3 Construct Model for HBR Scenars

For both the "guard" and the "stray" scenar, a complex and consistent construct model is defined. This model is described in Table 1.

Table 1: Description of constructs measured by HBR-Tools.

Construct	Content		
Decision finding		Heuristic competence (What is done?)	Modulation (How is it done?)
Planning	Searching, identification and evaluation of options to act		
Implementation	Implement options to act		
Intentions	Conscious selection of goals, setting priorities for goals and subgoals		
Situation awareness			
Analysis	Information gathering		
Mental Model	Anticipation of problems, control of background		
Reflection	Checking and evaluation of results		
Activity	Active handling of the situation		
Rule-conformity	Accounting for rules		
Risk-awareness	Accounting for risks		
Sharedness	Sharing own thoughts with others		

The organisation and definition of constructs is based on the HBR approach. Every single construct exists in two independent specifications. There is a positive as well as a negative specification so that the model as a whole includes 20 different factors. The idea behind the independence of the positive and negative aspects of the same constructs is that the information processing system in the background of the construct model allows showing either positive, negative or both specifications depending on the specific parameters of the system. For example, it might be that a candidate shows good rule-conformity in one moment and no rule-conformity in the next. Following the HBR approach this is something that must not be averaged out, but shows two different aspects of the information processing system. Clearly stated, it shows the range of parameter values a distinct aspect of the information processing system may take.

2.0 METHOD

The following section first describes the sample used in this study. Second it gives an overview of the basic structure of the scenars on which the statistical analysis relies upon.

2.1 Sample

Both the "guard" scenar and the "stray" scenar were given to a sample of applicants respectively members of German Special Forces. 49 subjects were tested with the "guard" scenar, 55 subjects completed the

"stray" scenar. All subjects were male, neither their age nor their educational level is known. The "guard" scenar was given to a sample of applicants for German army divers in addition. These 11 subjects were all male, too. Similarly to the first sample neither their age nor their educational level is known.

2.2 Statistical Analysis

Statistical analyses for both scenars were based on so called behavioural markers. These were defined as follows. First, both scenars were divided in several scenar elements. These scenar elements include in the case of the "guard" scenar the different rooms of the stock building in which the guard can act as well as some distinguishable locations at the outside. In the case of the "stray" scenar, scenar elements are defined along the different contexts in which the candidate can show his personal abilities. For example, there is a scenar element named "meet the hooligans" and one named "person who can help find the way to the railway station".

Within these scenar elements specific behaviours can be observed. Concerning the "stray" element, a specific behaviour of the candidate might be to ask the members of his group for ideas to get to the railway station, another one might be to leave the group after one of the group members has had the accident. These different specific behaviours are called behavioural markers.

The first step in the development of the evaluation rules for the two scenars was to scan all different scenar elements for possible behavioural markers. In this first step there was no guidance with respect to what the behavioural markers might measure. Only the fact that a decision of the candidate (in the sense of PSI theory; Dörner, 1999) might result in a specific behaviour and the expectation that candidates might react differently in their respective behaviours is the rule for defining an action as a behavioural marker. A differentiation is made between behavioural markers that belong to exactly one scenar element and markers that occur in different scenar elements.

In a second step the behavioural markers were arranged with respect to the construct model shown in table 1. Besides the allocation to a specific construct a decision had to be made if the behavioural marker defines either the positive or the negative aspect of the construct.

It is important to notice that both the definition of behavioural markers and the allocation of behavioural markers to a specific construct are preliminary. Up to now, the theoretical basis for measuring personality in an objective simulation of a more or less military situation is small. Rarely information can be given about behavioural aspects that are able to reflect personal abilities. So this study cannot rely on a strong theoretical foundation, since one of its goals is to produce such a foundation or at least makes one step in this direction. If this study is successful it can serve as a basis for future research with a more fine-grained goal structure.

As an example of behavioural markers in the "guard" scenar that belong exactly to one scenar element, the behavioural markers for the first element "guard-room" are named here:

- Looks around in the room (Constructs: Activity +, Analysis +)
- Takes torch (Constructs: Planning -, Activity +, Mental Model +)
- Switches-on torch while leaving the room (Constructs: Risk-awareness +)
- Opens door < 2 minutes (Constructs: Activity +, Rule-conformity +)
- Opens door with switched-on torch (Constructs: Risk-awareness +, Mental Model +)
- Tests torch (Constructs: Analysis +)
- Turns the radio down (Constructs: Implementation +, Activity +, Mental Model +)
- Leaves guard-room (Constructs: Implementation +, Activity +, Intentions +, Rule-conformity +)

- Opens door several times (Constructs: Implementation +)
- Torch switched-off while leaving the guard-room (Constructs: Risk-awareness -, Mental Model -)

The alternative of defining behavioural markers that are relevant in several scenar elements can be demonstrated by describing some of the markers in the "guard" scenar (for the sake of simplicity without naming the respective constructs):

- Reads instructions first time
- Reads instructions repeatedly (beyond three times)
- Sounds the alarm
- Sounds the alarm hastily
- Waits for the police
- Protocols controlling of interior rooms (after investigating them)
- Protocols controlling of interior rooms (without investigating them)
- Protocols controlling of outside area
- Tiptoes (> 10 sec)
- Walks without tiptoeing (> 10 sec)
- …

By splitting both scenars in several scenar elements and defining behavioural markers for every scenar element all requirements are fulfilled to measure personality aspects.

3.0 RESULTS

The following section shows the results for the "guard" and the "stray" scenar. Both scenars are separately analyzed. The order of analysis is as follows.

First, variation of the reactions with respect to each behavioural marker is checked. Since this is a first evaluation of the simulations, this is a very important step. Only behavioural markers with ample variation can reflect real-life differences in personal abilities between persons. In classical item analysis procedures, an often used criterion for ample variation is the usage of item means between M = .20 and M = .80. Because of the evaluative nature of this study and the relatively small sample size this criterion is widened and all behavioural markers are kept in the study with means between M = .10 and M = .90.

Second, the postulated construct model is evaluated. This is done by using structural equation modelling procedures (Joreskog, 1993). This is done despite the fact that the sample size is quite small. The idea is not to prove that the construct model holds with all facets but to get a first glance to what extent there are deviations from the model. The construct model can be analyzed in three different layers. At the first layer all single constructs independent of their positive or negative values are considered. So at this first layer there are 20 different models to analyze. At the second layer all behavioural markers developed for the positive and negative aspects of identically named constructs are combined. So at this layer there are 10 different constructs. At a third layer all ten constructs are united and analyzed together, so there is only one single big model to be analyzed at this layer. The models at the three layers are nested. This means that only if a successful analysis can be done at the first layer it is necessary to go on to the second layer. The fit of the model at higher layers cannot be better than the fit at earlier stages of the models.

Third, classical explanatory factor analysis is done to find out what potential alternative structure can be identified in the data. These analyses can be the base for further developments of the scenars. Explanatory

factor analysis is done by main component analysis using varimax rotation. Criterion for extraction of models is the scree plot.

Table 2: Results of SEM - "Guard" scenar [1]).

Nr.	Factor	Number of Indicators	Chi-Square	df	p	GFI	CFI	RMSEA
1	Planning (positive)	5	-	-	-	-	-	-
2	Planning (negative)	2	-	-	-	-	-	-
3	Implementation (positive)	9	35.116	27	.136	.883	.709	.071
4	Implementation (negative)	2	-	-	-	-	-	-
5	Intentions (positive)	7	-	-	-	-	-	-
6	Intentions (negative)	3	-	-	-	-	-	-
7	Analysis (positive)	10	-	-	-	-	-	-
8	Analysis (negative)	3	-	-	-	-	-	-
9	Mental Model (positive)	12	-	-	-	-	-	-
10	Mental Model (negative)	11	-	-	-	-	-	-
11	Reflexion (positive)	1	-	-	-	-	-	-
12	Reflexion (negative)	2	-	-	-	-	-	-
13	Activity (positive)	10	63.051	35	.003	.846	.647	.117
14	Activity (negative)	6	-	-	-	-	-	-
15	Rule-conformity (positive)	8	-	-	-	-	-	-
16	Rule-conformity (negative)	7	19.977	14	.131	.914	.821	.085
17	Risk-awareness (positive)	11	-	-	-	-	-	-
18	Risk-awareness (negative)	8	-	-	-	-	-	-

[1]) "-" in the columns for the fit indices indicate that the respective model couldn't be estimated. Explanations are given in the text.

3.1 The "guard" Scenar

Concerning the variation of the answers 43 of the 77 behavioural markers measured reach the criterion of mean between M = .10 and M = .90. Ten of them are measured in several scenar elements, eight belong to scenar element I, three belong to scenar element II, six belong to scenar element III, one belongs to scenar element IV, two belong to scenar element V, eight belong to scenar element VI and five belong to scenar element VII. Concerning the distribution of behavioural markers across the different scenar elements, a noticeable reduction of behavioural markers in scenar elements II, IV and V must be mentioned. In order to construct an effective and efficient measurement instrument this should be corrected in later versions of HBR-Tools.

The postulated construct model is evaluated using the 43 behavioural markers that remain after analyzing the variation of the behavioural markers. The fit of the structural equation models (SEM) used is investigated through Chi-square, GFI, CFI and RMSEA. For the guard scenar 18 of the possible 20 constructs at the first level are relevant. The construct "Sharedness" (positive and negative) is not measured because of its interactive character, while the guard has to walk alone through the scenar. Table 2 shows the results of SEM.

Only three of the 18 models could be estimated. Three possible reasons can be given for that. First, the sample size is small for using SEM. This might lead to estimation problems. Second, the reduction of behavioural markers through variation analysis leads for a couple of scales to a number of indices lower than four. For these scales a stable estimation is problematic. Third, some of the behavioural markers belonging to one scale correlate r = 1.0. Models with this characteristic cannot be estimated. The second and third reason call the postulated construct model into question. Because these two reasons are valid for all 15 models that are not estimated and due to the fact that the remaining three models don't have satisfactory fit indices the postulated model must be questioned. Despite the preliminary character of the analysis made here the character of the results indicate that the construct model must have a substantially different character.

Hence the 43 behavioural markers remaining after variation analysis are used in explanatory factor analysis. The scree plot indicates six factors. These factors can be given nameable content after varimax-rotation. The meaning of the factors and the allocation of behavioural markers to the factors are shown in table 3.

Table 3: Explanatory factor analysis – "Guard" scenar.

Factor	Naming	Behavioural Markers
1	Risk-aware investigation behaviour – General aspects	- gun not hold ready - gun hold ready - risk-aware investigation - thoroughness - goes directly to the outside area - door of the sensible room - protocol "indoor rooms" ok
2	Preparing for investigations	- opens door < 2 min - tests torch - opens door several times - torch switched-off while leaving the room - torch switched-on while leaving the room - takes torch - goes into the guard-room - opens door while torch is switched-on - turns down radio (<20%)
3	Risk-aware investigation behaviour – Concrete aspects	- closes the door - does not tiptoe (10 sec) - switches-on light - door of sensible room not tested - waits >20 sec - overhasty alarm - switches-off light - door to outside area not closed - gun hold ready

Table 3: Explanatory factor analysis – "Guard" scenar, continued.

Factor	Naming	Behavioural Markers
4	Consideration of general framework	- reads instructions first time - doesn't read instructions - protocol „indoor rooms" not ok - tiptoes (10 sec) - opens door quietly - opens protocol - looks around in the room - doesn't see hole in the fence
5	Handling of concrete danger	- gun not hold ready while seeing the burglar - doesn't pull gun - sees burglar - notices window - asks: Who are you? - walks away
6	Handling of concrete danger	- pulls gun - pushes alarm button - alarm button - says: hands up - torch stays switched-on - doesn't follow burglar - speaks while gun is pulled - door of sensible room

Following the results of explanatory factor analysis, the "guard" scenar offers the possibility of measuring different aspects of risk-aware investigation behaviour. The six factors identified can be allocated to five different aspects with regard to content.

3.2 The "stray" Scenar

Only 17 of the 51 behavioural markers show ample variation. Concerning the postulated construct model this reduction leads to the problem that for a large number of the constructs the number of behavioural markers is too small. For that reason the inspection of the postulated construct model is not carried out.

Although one of the tasks for further development of the "stray" scenar has to be the increase of the number of behavioural markers, the residual markers after the variation analysis were investigated through explanatory factor analysis. Only one factor can be extracted. In addition, this factor represents only eleven of the 17 behavioural markers remaining after variation analysis. The results are shown in table 4. Despite the fact that content can be found in the "stray" scenar, this content is based only on a minimal number of behavioural markers which calls the functioning of the scenar into question.

At the current stage of development the "stray" scenar can be seen as measuring communication and teamwork abilities. The postulated construct model could not be found at this time.

Table 4: Explanatory factor analysis – "Stray" scenar.

Factor	Naming	Behavioural Markers
1	Communication and teamwork	- Says: Can you show us the way to the railway station? - Says: Thank you for the location map. - Says: My friends do have a location map. Let's visit them - Says: Please show the pedestrian the location map, so he can show us the way. - Candidate doesn't speak to the pedestrian - Says: Sorry, I don't have a location map. Good bye! - Candidate is not near his group - Candidate follows the group - Candidate catches up to the group - Says: Please calm down. We don't want any trouble. - Takes flight

4.0 DISCUSSION

For both scenars, different conclusions must be drawn out of the analysis.

4.1 The "guard" Scenar

First, a revision of the scenar seems to be necessary. The number of behavioural markers is substantially reduced through variability analysis. This means reduction of efficiency and effectiveness. In addition, with respect to the measurement model the number of behavioural markers is not big enough. The revision is necessary, too, because a substantial number of behavioural markers show very high correlations. As a result of a revision, a finer measurement model with optimally allocated behavioural markers must be developed.

The confirmatory and exploratory factor analyses have shown that the postulated construct model could not be found in the data. The alternative results of exploratory factor analysis offer an interesting alternative construct model. Risk-aware behaviour becomes more and more important the higher the stakes will be in military applications. So a differential measurement instrument will be necessary for several applications. The recommendation after the analysis of these first data described here should be to further develop the measurement model of "risk-aware investigation behaviour" foreshadowed here.

4.2 The "stray" Scenar

The reduction of behavioural markers after the variability analysis is more distinct in the "stray" scenar than in the "guard" scenar. After the variation analysis only 17 indicators remain, wherefore the further SEM respectively explanatory factor analyses are based on a small basis. This leads to the question of efficiency and effectiveness of the "stray" scenar. Because of the high costs of development for the scenar, the number of measurement indicators isn't great enough. As far as the "stray" scenar is concerned, further recommendations for content development should wait until the number of suitable behavioural markers is substantially increased.

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